Virtual National Laboratory for Heavy Ion Fusion Sciences

Issue Number 4, Dec. 2008

HIFS News

Maxwell Prize awarded to HIFS VNL Deputy Director Prof. Ronald Davidson

According to the citation for the award, Ron was recognized "for pioneering contributions to the physics of one-component non-neutral plasmas, intense charged particle beams, and collective nonlinear interaction processes in high-temperature plasmas."

The 2008 American Physical Society James Clerk Maxwell Prize Award winner and HIFS VNL Deputy Director, Prof. Ronald Davidson. The Maxwell Prize is given annually "to recognize outstanding contributions to the field of plasma physics."

Grant Logan, Director of the U.S. Heavy Ion Fusion Science Virtual National Laboratory, said he and his staff are especially grateful for Davidson's important scientific contributions and wise guidance. "Because of Ron Davidson, we still have hope for the eventual fruition of heavy ion fusion," Logan said.

Additional information is available from the following web sites: http://www.pppl.gov/Davidsonnews08.html, http://www.aps.org/programs/honors/prizes/prizerecipient.cfm?name=Ronald%20C.%20Davidson&year=2008.

The HIFS VNL 2008 year in review

In 2008, the Heavy Ion Fusion Science Virtual National Laboratory made significant progress towards its goals of developing an ion beam based approach for studying High Energy Density Physics (including Warm Dense Matter Physics) and exploring new approaches to Heavy Ion Fusion (HIF). The Neutralized Drift Compression Experiment (NDCX-I) (using a novel technique that neutralizes the beam during drift compression and final focus to radically reduce the effects of the beam's own space charge) delivered ~2 ns pulses with mm-scale beam radii to planar targets. For the first time in the HIF program, target measurements were made to characterize the dynamic and thermodynamic response of these targets to the bombardment by a beam.

Part of the quantitative progress over the last year is exemplified in the successful completion of quarterly milestones that are reported to the US Department of Energy. Excerpts from the abstracts of the milestone reports that were reported in 2008 and links to the full reports are given below:

FY 2008 Q2-March 2008: Use beam steering dipoles to minimize aberrations associated with off-centered transit through the induction bunching module. Design an improved NDCX-I drift compression section to make best use of the new bunching module to optimize planned initial NDCX-I target experiments. This milestone was met by: (1) calculating steering solutions and implementing them in the experiment using the three pairs of crossed magnetic dipoles installed in between the matching solenoids, S1- S4. We have demonstrated the ability to center the beam position and angle to <1mm and <1mrad upstream of the induction bunching module (IBM) gap, compared to uncorrected beam offsets of several millimeters and milliradians. (2) Based on LSP and analytic study, the new IBM, which has twice the volt-seconds of our first IBM, should be accompanied by a longer drift compression section in order to achieve a predicted doubling of the energy deposition on future warm-dense matter targets. This will be accomplished by constructing a longer ferro-electric plasma source. The peak bunched current is a function of the longitudinal phase space and emittance of the beam entering the IBM. We have also characterized the longitudinal phase space with a high-resolution energy analyzer (See figure 1 for a photograph of NDCX-1).
The complete milestone report can be downloaded at:
http://hifweb.lbl.gov/hifnews/attachments2009/FY08Q2reportHIFSVNL.pdf

For comments about the content of the HIF News, contact Jean-Luc Vay (Cell 248-961-9115) or JLVay@lbl.gov

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FY 2008 Q3-June 2008: Complete fabrication of target experimental chamber and implement initial target diagnostics to be used for the first target experiments in NDCX-1. This milestone was met by completing the fabrication of a new experimental target chamber facility for future Warm Dense Matter (WDM) experiments, and by implementing initial target diagnostics to be used for the first target experiments in NDCX-1. The target chamber has been installed on the NDCX-I beamline. This achievement provides to the HIFS-VNL unique and state-of-the-art experimental capabilities in preparation for the planned target heating experiments using intense heavy ion beams.
The complete milestone report can be downloaded at:
http://hifweb.lbl.gov/hifnews/attachments2009/FY08Q3reportHIFSVNL.pdf

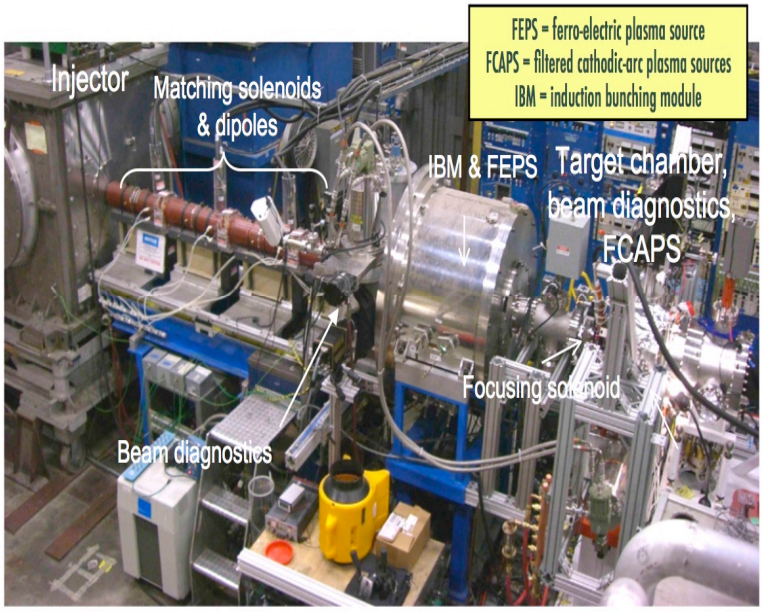

Figure 1. The Neutralized Drift Compression Experiment (NDCX-1).

FY 2008 Q4-September 2008: Carry out initial target experiment in the new target chamber, using beams compressed and focused by an improved bunching waveform and a final focus solenoid. This milestone has been met by making the target chamber and diagnostics fully operational and by performing the first target experiments heating thin gold foils using beams focused by a final focus solenoid and compressed by an improved bunching waveform. Initial experiments have demonstrated the capability of the NDCX beam to heat bulk matter in target foils. The experiments have focused on tuning and characterizing the NDCX beam in the target chamber, implementing the target assembly, and implementing target diagnostics in the target chamber environment (See figure 2 for an example of a recent target experiment showing continuous emission transitioning to emission lines from a vaporized gold target).
The complete milestone report can be downloaded at:
http://hifweb.lbl.gov/hifnews/attachments2009/FY08Q4reportHIFSVNL.pdf

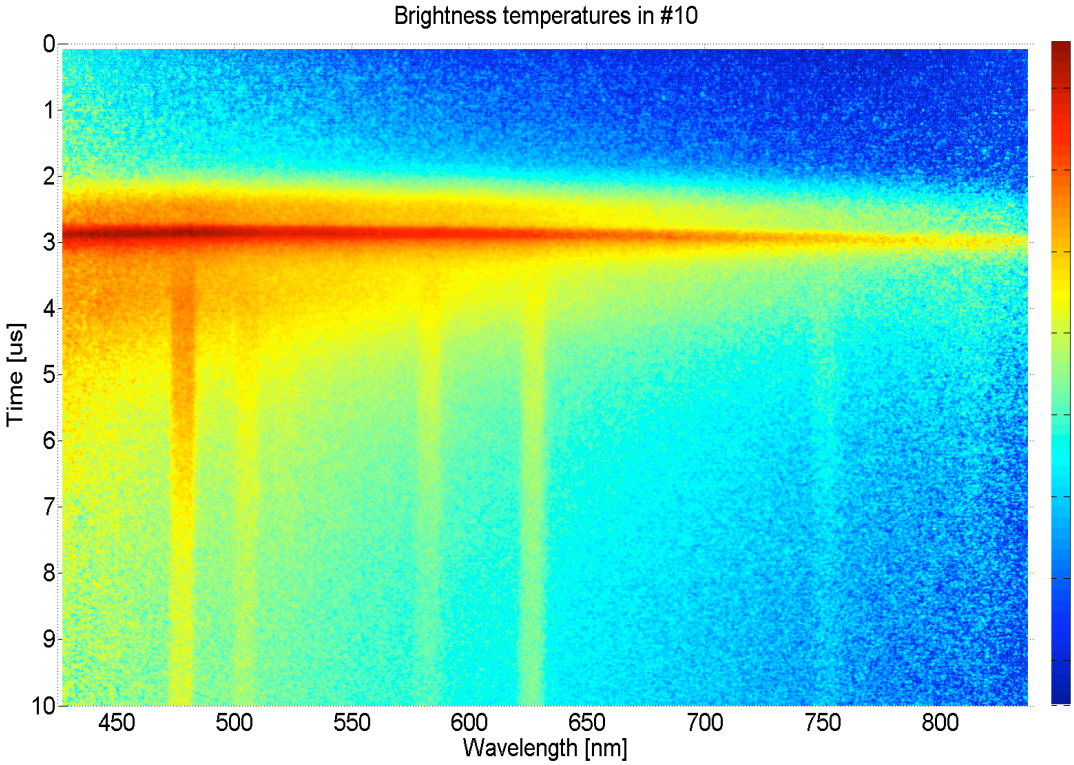

Figure 2. Brightness temperature [K] from streak-spectrometer data in Au target showing emission lines from heated gold. The uncompressed pulse heats the target over a period of several microseconds to the indicated temperature and the compressed pulse causes the spike in brightness temperature at about 3 μs.

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FY 2009 Q1-December 2008: Simulate beam neutralization near target focus using reconfigured plasma sources. This milestone has been accomplished: Particle-in-cell simulations have clarified the effects on the beam that arise from localized regions of incomplete neutralization along the beam path. The beam focal spot size increases and the peak intensity on target decreases when such regions are present. The results clarify the influence of regions where additional plasma sources would improve the beam focusing. The advantage of additional plasma sources has been demonstrated by comparing results obtained with and without plasma in regions where it is presently absent or under-dense. We have found that, in particular, directly introducing plasma into the region immediately upstream of the final-focusing solenoid, and at larger radii within that solenoid, would be beneficial. The implications of this work for the NDCX experiments are discussed. (See figure 3 for an example of a WARP simulation of plasma injection.)

The complete milestone report can be downloaded at:
http://hifweb.lbl.gov/hifnews/attachments2009/FY09Q1reportHIFSVNL.pdf

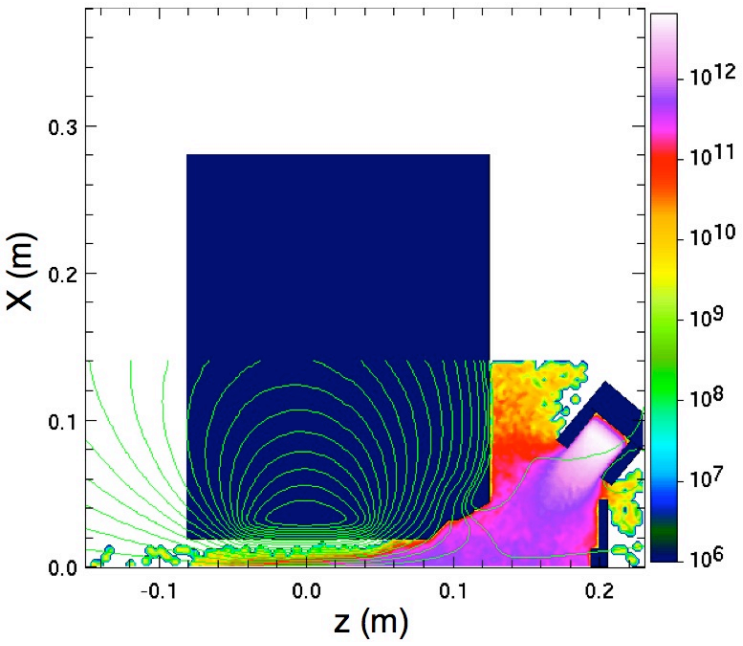

Figure 3. Snapshot at 7.5 μs from 3-D Warp simulation of plasma injection from four Cathodic Arc Plasma Sources. Colors denote electron number density in cm^{-3} (see scale); Magnetic field lines from solenoid (including effects of eddy currents) are shown in green.

Additional significant HIFS-VNL accomplishments in 2008 include:

- The hosting of the first Warm Dense Matter school at LBNL, January 10 – 16, 2008, with 92 registered participants from around the world. The school agenda and talks may be found at: http://hifweb.lbl.gov/wdmschool
- Presentation of at least 20 papers (including 16 invited talks) at the 17th International Symposium on Heavy Ion Inertial Fusion held August 4-8, 2008 in Tokyo, Japan: http://hifweb.lbl.gov/public/HIF2008/
- Presentation of three papers (including two invited talks) at LINAC08 in Victoria, Canada, Sept. 29 – Oct. 3, 2008: http://hifweb.lbl.gov/monthlyreports/2008.11/
- Presentation of at least 23 papers (including 3 invited talks) at the American Physical Society Division of Plasma Physics, November 17 – 21, 2008 in Dallas, Texas. One of the invited papers was Ron Davidson's Maxwell Prize acceptance talk (see article in this issue).
http://hifweb.lbl.gov/hifnews/attachments2009/VNLAPSDPP2008.pdf
- On December 18-19, 2008, the HIFS VNL hosted the 11th US-Japan Workshop on HEDP and HIF, at LBNL and LLNL. Sixteen presentations and tours of the NDCX and NIF facilities were given: http://hifweb.lbl.gov/public/USJapanWorkshop2008
- The HIFS-VNL completed a major twenty-year research plan as a white paper and basis for a presentation to the FESAC HEDLP panel: http://hifweb.lbl.gov/public/papers/HIFSwhitepaper.pdf
- The HIFS-VNL developed and used state-of-the-art hydro-code capability for design of beam driven WDM targets, NDCX-II direct drive experiments, and heavy ion fusion targets:http://hifweb.lbl.gov/hifnews/attachments2009/FY08TargetSimulations.pdf
- Simulation and design support for NDCX-I and NDCX-II. In particular, the NDCX-II design shows an efficient use of existing ATA induction modules to both rapidly compress and accelerate intense heavy ion beams:
http://hifweb.lbl.gov/hifnews/attachments2009/FY08SimulationDesignforNDCX.pdf
- Several FY08 advances in the WDM Target area supported the HIFS-VNL goals:
http://hifweb.lbl.gov/hifnews/attachments2009/FY08WDMTargetGrpaccomplishments.pdf
- A conceptual breakthrough in high coupling efficiency for heavy ion direct drive was discovered in FY08 and published: http://link.aip.org/link/?PHPAEN/15/072701/1
- An advanced heavy-ion fusion test facility/power plant concept was developed and presented to TOFE this year:
http://hifweb.lbl.gov/hifnews/attachments2009/LoganTOFE2008.pdf

- John Barnard and Grant Logan (on behalf of the HIFS-VNL).

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